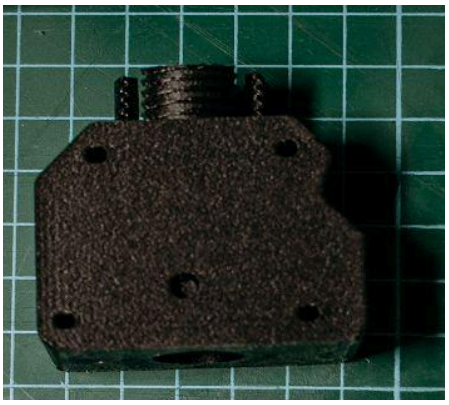
3D-print materials

The team carefully studied multiple filaments for each part of the drone. The most important parameters were stiffness, impact strength, bending strength, and temperature resistance, as well as moisture absorption. The expected parameters differ between parts.

For the arm mounting element, the team chose PA12+CF15 filament. It was the stiffest filament the team could buy within its budget (Tensile Modulus: 7995 MPa). It also had great Charpy impact strength (73 kJ/m2). Its biggest drawback was shrinkage, but switching brands for this filament solved the problem - the second choice printed much more easily. The tricky part of this element was that it contains a thread. To keep the proper shape, it had to be printed bottom to top, which posed a risk of breaking along the thread layers, since the threads run parallel to the Z-axis and create weak spots at the layer connections. Fortunately, this material has strong layer cohesion, which keeps the layers intact.

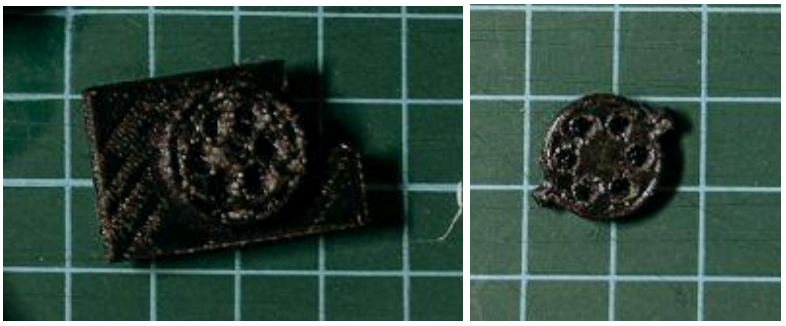


The female mounting element with thread.

The next challenge was to choose the material for the cap. The most questionable part was whether threads of different materials on the arm connector and cap would intermate. The team prototyped with PETG, as it is cheaper than PA12+CF15, but still strong. In the first iterations, it broke on the layers' connection due to the Z-axis, which was expected. But the team managed to overcome this by creating a two-part cup, thereby reducing friction during tightening. Moreover, thanks to this solution, the attachment can be easily replaced with a new one without having to dismantle the engines or the entire arm mounting mechanism.

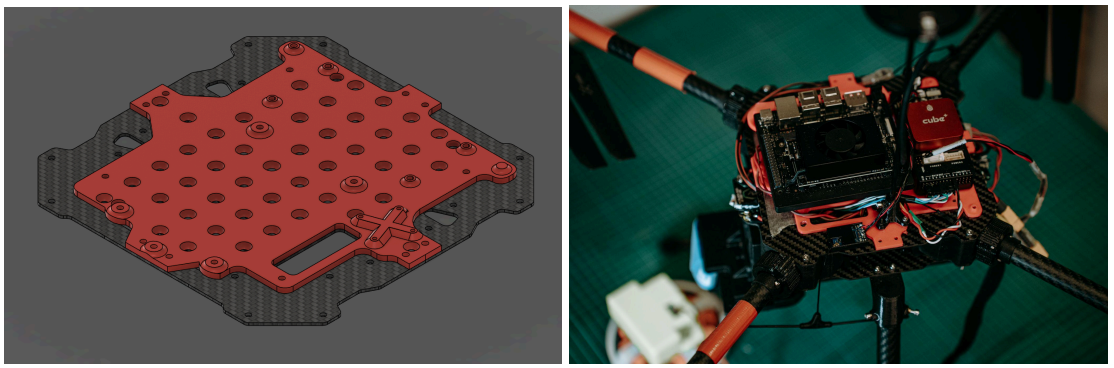
Iterations of the cap - from first to the final.

For the custom cable connector in the arms, the team chose TPU 85A filament, since it needed to absorb vibrations from the engines. In that way the team managed to reduce friction between molex female and male pins. The risk of the arm hanging on the connector is significantly reduced thanks to the use of TPU filament. The arms' strength is entirely based on the PA12+CF15 mounting mechanism. The connectors were hard to print due to accurate dimensions. The printer had a 0,2 mm nozzle which is not recommended to use when printing TPU. It may cause clogging which stops printing. To avoid this issue printing is so slow that the whole process of printing 10,87g elements takes around 14h. To achieve better quality retraction is a little bit higher. It reduces a side effect called stringing.



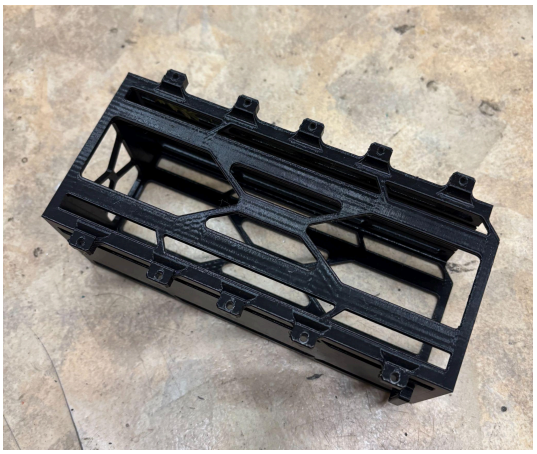
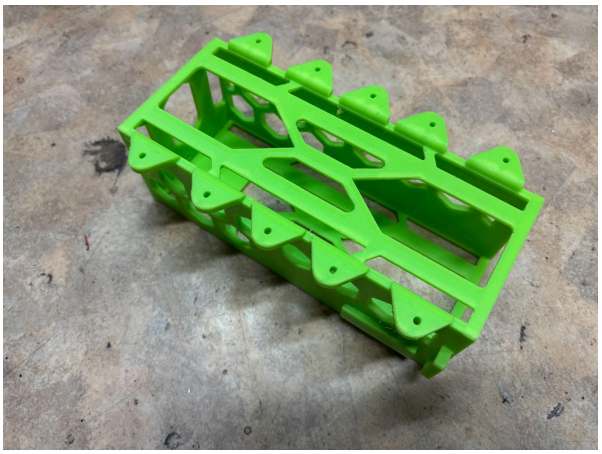
TPU-printed parts for female and male plug.

At the top part of the drone, there is a 3d printed plate designed by the team to distribute electrical components like FC, compass and GNSS, minicomputer etc.. As it is an element that doesn't need to be either stiff or strong, the team could have printed it with easy, cheap PLA filament. But the temperatures in Oklahoma made that impractical. PLA's glass transition temperature (T_K) is only 55°C, far too low given how hot it can get inside a car on a summer day. So the team chose ASA instead. It resists 85°C, and it's also lighter than PETG.



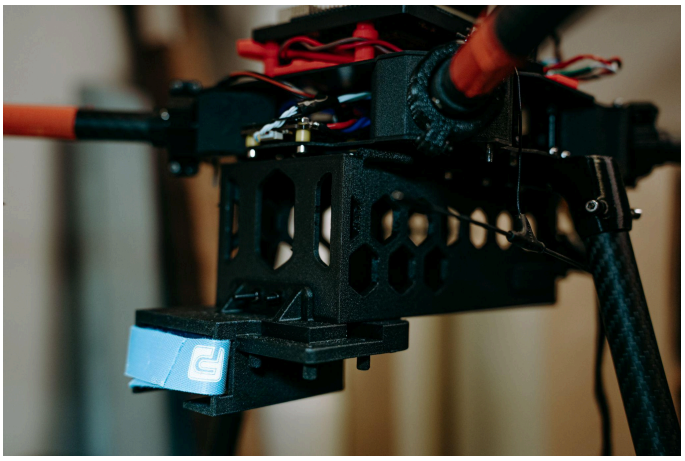
The top plate. Design in Fusion and print mounted on the drone.

For the battery container that also holds the payloads, the team chose PA12+CF15 again. It was first prototyped in PETG filament, as it is the largest printed part and polyamide filament is expensive, but the construction broke after a single impact from a height of 1m.

The first and second iteration of the battery bay.

Polyamide proved much stronger and was chosen for this part instead.



The battery bay.

For the release-drop mechanism parts attached to the objects, the team chose TPU 96A filament. As this part needs to survive the impact from the drone at 60m without harming anyone nearby, the elastic properties of TPU made it the best choice.

PA12+CF15 was also chosen for the leg connectors, since they absorb the forces from ground impact and support the engine mounts - parts that can easily break on impact if the material isn't strong enough.